LVI.—*Remarks on the Subject of* "Eozoon."

By Prof. King, D.Sc., and Prof. Rowney, D.Ph.

We have no intention of entering on the discussion opened up by Mr. Carter, F.R.S. &c., in his letter to one of us, and the reply to it by Dr. Carpenter, that have lately appeared in the 'Annals;' feeling satisfied that the constructors of the so-called *Eozoon canadense* have quite sufficient to attend to in answering the evidences and arguments already brought forward in the papers we have published against its presumed organic origin. Hitherto, and we regret to say it advisedly, no proper attempt has been made to do so.

In our early investigations, and after having fully satisfied ourselves that the various eozoonal structures could not be the remains of an organism, we felt it to be our duty to make an attempt at explaining their mineral origin. They looked much like dendromorphs and acicular crystallizations; but we soon found that they were not productions of these kinds, nor concretions, nor infiltrations: instead of being incremental, they were obviously decremental. Consisting for the most part of serpentine (an amorphous hydro-silicate of magnesia), this mineral was seen to be affected by an irregular septarian and a subparallel divisional structure, accompanied by some remarkable changes, one fibrous (known to mineralogists as chrysotile), another arborescent (? metaxite), and another flocculent—all usually of a white colour. Very frequently calcite prevails in the divisional interspaces in association with the latter allomorphs. In such cases the serpentine is broken up into irregularly lobulated or segmented grains, lumps, and plates, separated by the calcitic interspaces; in which are imbedded examples of the three allomorphs: the chrysotile is generally an integral portion of the grains and plates of serpentine, forming patches of asbestiform coating. The plates of serpentine and their calcitic interspaces occasionally give rise to remarkable interlaminations, while the grains (usually attached to one another, but occasionally isolated) occur irregularly scattered amongst the calcite. Not unfrequently the serpentine assumes the condition of chrysotile *without any calcite being present*. A close investigation enabled us to see not only the serpentine passing insensibly into compact or true chrysotile and flocculite (as, for the sake of brevity, it may be called), but that the one often became separately acicular, and the other changing from rudely shaped masses into simple and complex arborescences (like those in metaxite), simulating, in the most remarkable manner, sponge-structures and dendritic crystallizations. The evidences were so clear and

complete as to prevent our coming to any other conclusion than that they were residual bodies, and not concretions, infiltrations, or crystallizations. As to their being portions of an organism, the idea would not bear any serious consideration. Wherever the changes had taken place, a carbacid mineral (calcite, or dolomite) had replaced the chrysotile, flocculite, and metaxite; so that it became evident that we had before us the results of chemical changes analogous to certain kinds of pseudomorphosis occurring among minerals.

Not only does serpentine present unmistakable evidences of the above changes, but certain of them have occurred to us in other silacid minerals, as malacolite and Wollastonite. Agglomerations of minute crystals of these minerals are common in certain so-called primary limestones (notably at Aker in Sweden, Amity in New York, and in Ceylon), so reduced by solvent or chemical action (the component crystals still retaining in many cases their original angles, edges, and planes) as to assume the exact forms of the "eozoonal canal-system" in its typical condition, and showing clearly their residual character, also the replacement of their lost or eroded portions by the calcite or dolomite in which they are imbedded.

A more important discovery we had not anticipated. It opens out a wide field of research in chemical geology, an insight into which, however, has been afforded by the illustrious Bischof. Of late the subject has been frequently under our consideration. It is well known that certain rocks are not in their original chemical condition: the changes in serpentine render it extremely probable that ophite (a silocarbacid rock) is a chemically changed or methylotic product, that the Tyree, Aker, and other crystalline marbles were originally silacid masses, and possibly that much of the so-called "limestones" occurring in the Laurentians of Canada were, in Archæan periods, silacid members of true gneisses, diorites, and other related rocks*. We need not dwell any longer on this subject; suffice it to say that we are pursuing a number of researches in connexion with it. We have been favoured with specimens by Mr. F. R. Mallet, of the Indian Geological Survey, discovered by himself in dolomitic bands intersecting transversely beds of gneiss at South Mirzapur†, showing typical eozoonal structures beautifully developed through methylotic action; and last summer one of us obtained at the Lizard, Cornwall, aided by the kindness of Mr. Symons, manager of the Poltesco marble-works, a number of speci-

* See a paper by one of the writers in the 'Geological Magazine' for January 1872.

† Records of the Geological Survey of India, No. 1, 1872.

mens out of apparently a most unpromising rock (serpentinite, rarely including any carbacid members), showing its characteristic mineral not only changing as "eozoon" into calcite, but also as a pseudomorph after augite, &c. A description of these cases is in preparation for publication.

Our view is that the changes referred to have resulted from the action of heated water holding a carbonate in solution.

But to return to "*Eozoon*." Dr. Carpenter has kindly offered "to give time and trouble to enable those who wish to make the comparison of actual specimens for themselves." We would strongly urge on them to take advantage of this offer. We may be permitted, however, to supplement it by suggesting their careful perusal of the memoirs that have been published by us descriptive of similar specimens*, not forgetting those published by Dr. Carpenter and others on his side.

Attention may next be called to the following summary of the arguments and evidences contained in the memoirs referred to:—

1st. The serpentine in ophitic rocks (consisting essentially of serpentine and calcite, with which various other minerals, chiefly silacids and carbacids, are often associated) we have shown to present appearances which can only be explained on the view that it has undergone structural and chemical (methylotic) changes:—the former causing it to pass into different subdivided states; and the latter etching out the resulting solids into a variety of forms—grains and plates with lobulated or segmented surfaces ("chamber-casts," see Dr. Carpenter's fig. 1), fibres and aciculæ ("nummuline chamber-wall"), simple and branching configurations ("canal-system"). Crystals of malacolite and other silacid minerals (often occurring in ophite and other silo-carbacid rocks) manifest some of these changes in a remarkable degree.

2nd. The "intermediate skeleton" of "*Eozoon*" (which often appears as the calcitic matrix of the above lobulated grains &c.†) is completely paralleled in various crystalline rocks, notably marble containing grains of coccolite (Aker and Tyree), pargasite (Finland), chondrodite (New Jersey), &c.

3rd. The "chamber-casts" in the granular (acervuline) variety of "*Eozoon*" are more or less paralleled by the grains of the silacid minerals in the precited marbles.

* Quarterly Journal of the Geological Society, vol. xxii.; 'Proceedings of the Royal Irish Academy,' vol. x.; *ibid.* new series, vol. i.; 'Geological Magazine,' January 1873.

† This part is dissolved out (artificially) in fig. 1. Dr. Carpenter's fig. 2, exhibiting the various eozoonal features, must be taken merely as an illustration, it being a *constructed* representation.

4th. The "chamber-casts" being composed occasionally of Loganite and malacolite (besides serpentine) is a fact which, instead of favouring their organic origin as supposed, must be held as a proof of their having been produced by mineral agencies, inasmuch as the three silacid minerals named have a close pseudomorphic relationship, and may therefore replace one another.

5th. Dr. Gümbel, observing rounded, cylindrical, and tuberculated grains of coccolite and pargasite in crystalline calcitic marbles, considered them to be "chamber-casts," or of organic origin. We have shown that such grains often present crystalline planes, angles, and edges—a fact clearly proving that they were originally aggregations of simple or compound crystals that have undergone external decretion by chemical or solvent action.

6th. We have adduced evidences to show that the "nummuline chamber-wall"* in its typical condition (that is, consisting of cylindrical aciculæ separated by interspaces filled with calcite) has originated directly from closely packed fibres, these from chrysotile or asbestiform serpentine, this from incipiently fibrous serpentine, and the latter from the same mineral in its amorphous or structureless condition †.

7th. The "nummuline wall," in its typical condition, unmistakably *occurs in cracks or fissures*, both in Canadian, Connemara, and other ophites ‡.

8th. The "nummuline wall" is paralleled by the fibrous coat which is occasionally present on the surface of grains of chondrodite §.

9th. We have shown that the relative position of two superposed acicular layers (an *upper* and an *under* "nummuline wall"), and the admitted fact of their component aciculæ often passing continuously and without interruption from one "chamber-cast" to another, to the exclusion of the "intermediate skeleton," are totally incompatible with the idea of the said

* Quart. Journ. Geol. Soc. vol. xxii. pl. xiv. figs. 1 & 2; Proceedings Royal Irish Acad. vol. x. pl. xli. figs. 1 & 2. Few figures of the "chamber-wall," published by the constructors of "*Eozoon*," afford a proper idea of its structure. We were the first to represent it in its typical condition.

† The so-called "nummuline wall" (asbestiform coat) in Dr. Carpenter's constructed representation, fig. 2, ought not to be represented in the way it is—bounded by two *continuous* lines—as it is an *integral* portion of the grains and plates of serpentine (the so-called "chamber casts"), and not a *chemically* differentiated part like the true (calcareous) wall of certain Foraminifers.

‡ Quarterly Journal Geological Society, vol. xxii. pl. xiv. fig. 4, p. 196; Proc. Royal Irish Academy, vol. x. pl. xlii. figs. 5, 6.

§ Quarterly Journal Geological Society, vol. xxii. pl. xiv. figs. 5 & 6, pp. 196 & 197.

"nummuline layers" having resulted from pseudopodial tubulation*.

10th. The so-called "stolons" and "passages of communication exactly corresponding with those described in *Cyclo-clypeus*" (fig. 2, *b b*) have been shown to be tabular crystals and variously formed bodies belonging to different silacid minerals, wedged crossways or obliquely in the calcitic interspaces between the grains and plates of serpentine†.

11th. The "canal-system" is composed of serpentine, malacolite, and other silacid minerals. Its typical kinds in serpentine may be traced in all stages of formation out of plates, prisms, and other solids undergoing a process of superficial decretion ‡. In malacolite &c. they are made up of crystals (single or aggregated together) that have had their planes, angles, and edges rounded off, or have become further reduced by some solvent.

12th. The "canal-system," in its remarkable branching varieties, is completely paralleled by crystalline configurations in the coccolite marble of Aker, in Sweden, in the crevices of a crystal of spinel imbedded in a calcitic matrix from Amity, New York, and in a gemmiferous calcitic rock occurring in Ceylon§.

13th. The *configurations*, presumed to represent the "canal-system," are *totally without any regularity* in their form, relative size, or arrangement; and they occur independently of, and apart from, other "eozoonal features" (Amity, Boden, &c.),—facts not only demonstrating them to be purely mineral

* *Ibid.* vol. xxii. p. 191; Proc. Royal Irish Academy, vol. x. p. 517.

† Quarterly Journal Geological Society, vol. xxii. pl. xiv. figs. 10 & 11, pl. xv. fig. 15, pp. 207 & 208.

‡ Proc. Roy. Irish Acad. vol. x. pl. xliii. figs. 7 & 8, pp. 527 & 528. Speaking of the "arborescent structure" of the "canal-system," Dr. Carpenter assumes that we "maintain it to consist of mere *mineral infiltrations*"! And hence, by adopting the following mode of reasoning, he evidently feels that a decisive case has been made out against us. As the "ramifications pass across the planes of cleavage, every mineralogist will at once say that this is perfectly conclusive—against their being, by any probability, mere inorganic infiltration; that nothing but organic structures could in this manner produce a ramification of one mineral in the interior of another, a ramification of serpentine in the interior of carbonate of lime passing against its crystalline planes" ('Pharmaceutical Journal,' Feb. 11, 1871, p. 649). If this were the case, it would necessarily follow that imbedded minerals which produce "ramifications" in the "interior of calcite and passing against its crystalline planes" (as is common with native silver, prismatic pyrites, glauconite arborescences in calcite or the so-called Hislopite, the latter as made known by Mr. Carter) can be "nothing but organic structures"! It is to be regretted that Dr. Carpenter still makes use of this argument in his last communication.

§ Geological Magazine, January 1873. We have lately detected typical "canal system" in a chondrodite rock from the United States.

products, but which strike at the root of the idea that they are of organic origin.

14th. In answer to the argument that, as all the "eozoonal features" are occasionally found together in ophite, the combination must be considered a conclusive evidence of their organic origin, we have shown, from the composition, physical characters, and circumstances of occurrence and association of their component serpentine, that they represent the structural and chemical changes which are eminently and peculiarly characteristic of this mineral*. It has also been shown that the combination is parallel to a remarkable extent in chondrodite and its calcitic matrix†.

15th. The "regular alternation of lamellæ of calcareous and siliceous minerals" (respectively representing the "intermediate skeleton" and "chamber-casts") occasionally seen in ophite, and considered to be a "fundamental fact" evidencing an organic arrangement, is proved to be a *mineralogical* phenomenon by the fact that a similar alternation occurs in amphiboline-calcitic marbles and gneissose rocks‡.

16th. In order to account for certain *untoward* difficulties presented by the configurations forming the "canal-system" and the aciculæ of the "nummuline layer"—that is, when occurring as "*solid bundles*," or when they are "*closely packed*," or "*appear to be glued together*,"—Dr. Carpenter has proposed the theory that the sarcodic extensions which they are presumed to represent have been "turned into stone" (a "siliceous mineral") "by Nature's cunning" ("just as the sarcodic layer on the surface of the shell of living Foraminifers is formed by the spreading out of *coalesced* bundles of the pseudopodia that have emerged from the chamber-wall")—"by a process of chemical substitution *before* their destruction by ordinary decomposition"§. We showed this quasi-alchymical theory to be altogether unscientific‖.

17th. The "siliceous mineral" (serpentine) has been analogued with those (generalized as glauconite) forming the variously produced casts of recent and fossil Foraminifers. We have shown that the mineral silicates of "*Eozoon*" have no relation whatever to the substances composing such casts.

18th. Dr. Sterry Hunt, in order to account for the serpentine,

* Proc. Royal Irish Academy, vol. x. pp. 533, 534, 535.

† Quarterly Journal Geological Society, vol. xxii. pl. xiv. figs. 5 & 6, p. 197.

‡ Quarterly Journal Geological Society, vol. xxii. p. 210; Proc. Royal Irish Academy, vol. x. p. 523.

§ Intellectual Observer, vol. vii. uncoloured plate, fig. 2, *a*, pp. 292, 294, 290; Quarterly Journal Geological Society, vol. xxii. p. 222.

‖ Quarterly Journal Geological Society, vol. xxii. p. 202; Proc. Royal Irish Academy, vol. x. pp. 537 & 538.

Loganite, and malacolite being the presumed in-filling substances of "*Eozoon*," has propounded the "novel doctrine" that such minerals were *directly* deposited in the ocean-waters in which this "fossil" lived. We have gone over all his evidences and arguments without finding *one* to be substantiated.

19th. Having investigated the alleged cases of "chambers" and "tubes" occurring "filled with calcite," and presumed to be "a conclusive answer to" our "objections," we have shown that there are the strongest grounds for removing them from the category of reliable evidences on the side of the organic doctrine*. The Tudor specimen has been shown to be equally unavailable.

20th. The occurrence of the best-preserved specimens of "*Eozoon canadense*" in rocks that are in a "*highly crystalline condition*" (Dawson) must be accepted as a fact utterly fatal to its organic origin†.

21st. The occurrence of "eozoonal features" *solely* in crystalline or metamorphosed rocks belonging to the Laurentian, the Lower Silurian, and the Liassic systems‡ (never in *ordinary unaltered deposits* of these and the intermediate systems) must be assumed as completely demonstrating their purely mineral origin.

It is understood that a communication from Mr. Arthur Barker will appear, showing that, whatever opinion the late Professor Schultze might hold in the autumn of last year respecting "*Eozoon*," he subsequently changed it after reading our papers. As he expressed a wish to become fully acquainted with the "canal system," we were careful in sending him some instructive specimens exhibiting it in various stages of formation.

* Proceedings of the Royal Irish Academy, vol. x. pp. 532, 548; *ibid.* new ser. vol. i. p. 10. Dr. Carpenter (also Dr. Dawson) still adduces these unreliable cases, and ignores altogether the grounds on which we have considered them such.

† Dr. Carpenter, replying to the objection, as put by Mr. T. Mellard Reade, F.G.S., that "Eozoon" *only occurs in metamorphosed rocks* ('Nature,' No. 60), asserts that its "calcareous lamellæ" ("intermediate skeleton") "show less departure from the shelly texture than do the great majority of undoubted shells, corals, &c. contained in the least-altered rocks of any geological period" ('Nature,' No. 62)—forgetting that as the substance of such fossils has undergone so much change, the fact demands a vast amount of metamorphism to convert the rocks containing them ("least altered" as they may be) into the "highly crystalline condition" of "eozoonal" ophite. But Dr. Carpenter seems to misunderstand the objection altogether, as it is not based so much on the mineral structure of the "eozoonal features" as on the fact that they occur best preserved in "highly crystalline" or metamorphosed rocks.

‡ Proc. Roy. Irish Acad. vol. x., "Geological Considerations"; *ibid.* new ser. vol. i., "Isle of Skye Ophite."